

Heavy Metals Pollution and Trend in the River Nile System

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Abstract

Due to large amount of sewage of increased population, excessive use of pesticides and fertilizers in agriculture, rapid development of chemical and petrochemical industries and mining activities around the River Nile and its tributaries White Nile and Blue Nile, chemical water quality of those Niles are expected to be deteriorated. River Nile and its tributaries are among the main Khartoum state drinking water supply resources. The main aim of this study is to assess the concentration of heavy metals (in terms of lead Pb, cadmium Cd and chromium Cr) in the River Nile, White Nile and Blue Nile and compare the results of water analysis with the WHO guideline values. And then investigate the trend of heavy metals (in terms of lead and cadmium) in the White and Blue Niles. Three composites samples were collected from River Nile, White Nile and Blue Nile and examined using ICP by applying SOP- CIL-SP-02 test method to evaluate the concentration of heavy metals. Also a comparison study with previously obtained results was carried out. Heavy metals concentration in the River Nile, White Nile and Blue Nile in terms of cadmium, and chromium were found to be within the level according to WHO guidelines for drinking water, but for lead it was in the marginal level. However when comparing the concentrations obtained in this study with those in two previous studies, it was revealed that there is a regular built up of heavy metals concentration in the River Nile tributaries; White Nile and Blue Nile.

Keywords: Blue Nile; Chemical Water Quality; Heavy Metals; River Nile; Water Pollution; White Nile.

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1. Introduction

(Water is the most important natural resource in the world since without it life cannot exist. The presence of a safe and reliable source of water is thus an essential prerequisite for establishment of a stable community.

Water whether from ground or surface sources, found in nature is polluted [1]. The pollution is naturally arising from erosion, leaching and weathering processes or due to human activities (anthropogenic). Chemical pollution is one of the most serious pollution and has negative impacts on the water quality of all types of rivers.

There are many possible sources of chemical contamination such as chlorinated hydrocarbons waste from industrial chemical production, heavy metals contamination from metal plating operations, pesticides, fertilizer and salinity in the runoff from agricultural lands. Heavy metals such as lead, cadmium, chromium and mercury are among the most harmful elemental pollutants. Most of them have tremendous affinity for sulfur and attack sulfur bond in enzymes, thus immobilizing the enzymes. Protein carboxylic acid and amino groups are chemically bound by heavy metals [1].

River Nile and its tributaries White Nile and Blue Nile water quality is expected to be deteriorated gradually since a lot of human activities near the rivers banks and few kilometers from them have increased dramatically. Large amount of sewage due to increased population, excessive use of pesticides and fertilizers in agriculture, chemical and petrochemical industries and formal and informal gold mining are among the main activities expected to add chemical pollutants and negatively affect the chemical quality of the River Nile and its tributaries.

Khartoum state's main sources of water supply are the River Nile system and the ground water. Khartoum state is currently supplied about 52% by ground water and 48% by water extracted from the Nile River [2].

One of the main challenge facing water resources in Khartoum is pollution. Toxic and organic chemicals pose threat to the safety of water resources in Khartoum.

Few analytical studies were carried out to assess the chemical quality of drinking water resources in Khartoum state.

Bastawy conduct a thesis to assess the water quality of the River Nile around Khartoum city, and investigates eventual influences of the city on the River Nile by analysis of temperature, pH, conductivity, adsorb- able organic halogen (AOX), cadmium (Cd), lead (Pb), chromium (Cr), total organic carbon (TOC) and nitrate (NO₃). The analysis was carried out in 2006. It was concluded that the city Khartoum added small but legible concentrations of cadmium, lead, chromium and TOC to the River Nile. However, the resulting concentrations were all within acceptable levels. Also the observed results showed that the Blue and White Niles, which merge together upstream on the outskirts of Khartoum, had concentration of AOX and chromium which were not suitable for drinking water [3].

"Assessment of water supply sources and system of potable water in Khartoum metropolitan in relation to liquid

waste disposal" was a research carried out by the UNISCO Chair in Water Resources (UNISCO- CWR) in collaboration with different national water sectors and agencies. The objectives of the research were to assess and investigate the quality of drinking water sources in Khartoum metropolitan whether these sources are ground or surface and to study their vulnerability to the liquid waste disposal (Domestic, Industrial, agricultural or medical waste). Parameters investigated were physical parameters, chemical parameters (which included heavy metals, BOD and COD) and water microbiological parameters. The research concluded that the water quality of River Nile and its tributaries (Blue and White Niles) generally complies with standards and specifications for sources of drinking water quality except for turbidity, BOD and bacterial analysis. It also concluded that the ground water source in Khartoum area is influenced adversely by the use sewage and excreta disposal in terms of high level of BOD, NO₃, coliform and E- coli concentrations. With regard to heavy metals, the study concluded that Khartoum State water sources are safe from heavy metals pollution [4].

Another study was carried out to investigate the level of heavy metal pollution of the White Nile River. Three locations were selected to represent high, medium and low pollution-risk areas. Location 1, in the river port town of Kosti, represented a high pollution locality. Location 2 at Elfeteihap, near an industrial area in the capital city, Khartoum, was a medium pollution-risk area. Location 3, at the Elshagara research station south of Khartoum, represented areas considered to be at lowest risk of heavy metal pollution. At each location, concentrations of the heavy metals copper (Cu), cobalt (Co), lead (Pb), cadmium (Cd) and nickel (Ni) were measured in water and sediment samples as well as in the flesh of a bioindicator fish, the Nile Tilapia (*Oreochromis niloticus*), using atomic absorption spectroscopy.

Fish sediment and water samples collected from Location 1 showed the highest level of contamination with heavy metals. Accumulation of heavy metal contaminants in fish samples from this area was associated with their concentration in sediment and water. The high levels contamination was attributable to oil spills and other activities at the river port. Because the concentrations of heavy metal contaminants were found to be less than the permissible values recommended by the FAO/WHO reports, they concluded that water and fish from the sampled areas of the White Nile are safe for human consumption. [5]

The main aim of this study is to assess the concentration of heavy metals (in terms of lead Pb, cadmium Cd and chromium Cr) in the River Nile system and its tributaries; White Nile and Blue Nile and compare the results of water analysis with the WHO guideline values [6]. And then investigate the trend of heavy metals (in term of lead Pb and cadmium Cd) in the White Nile and Blue Nile by comparing their concentrations in this study with those obtained from two previous studies.

Based on the objective, this study confines itself to the River Nile, White Nile and Blue Nile within the Khartoum city.

2. Materials and methods

To realize the objective of this study, a quantitative analysis on the concentration of heavy metals (lead Pb, cadmium Cd, and chromium Cr) was investigated in the River Nile and its tributaries; White Nile and Blue Nile.

Then a comparative study of the result obtained and those obtained from the previous studies were carried out to investigate the trend of heavy metals concentration in the River Nile system.

2.1. Sampling procedure

Fifteen grab samples were collected in May 2016 from three locations, the River Nile (about 3 Km from Almogran) White Nile (about 3 Km from Almogran) and Blue Nile (about 3 Km from Almogran), at 1 meter depth and about 30 m from river banks and then mixed together to make one composite sample for each location. (Almogran is the point where the White Nile and Blue Nile meet to form the River Nile).

2.2. Sampling analysis

Samples were examined using ICP by applying SOP- CIL-SP-02 test method to evaluate the concentration of heavy metals.

3. Results and discussion

Concentrations of lead Pb, cadmium Cd, and chromium Cr detected in the River Nile, White and Blue Niles during this study and the guideline values of WHO were tabulated in table (1).

Table 1: Concentrations of Pb, Cd, and Cr in the River, White and Blue Niles and the guideline values of WHO

Parameters	River Nile	White Nile	Blue Nile	WHO guideline values
Pb (mg/l)	<0.0148	<0.0148	0.01049	0.01
Cd (mg/l)	<0.0009	<0.0009	<0.0009	0.003
Cr (mg/l)	0.0037	0.0019	0.0117	0.05

This result is represented graphically as shown in figure (1).

It is clear that from table (1) and figure (1) that the concentrations of cadmium and chromium in the River Nile and its tributaries were still below the guideline values stated by WHO for heavy metals in drinking water. Cadmium concentration detected in River Nile, White Nile and Blue Nile was below (0.0009 mg/l) and according to WHO guideline values the recommended level is (0.003 mg/l). The level of chromium in the River Nile, White Nile and Blue Nile were (0.0037, 0.0019 and 0.0117 mg/l) respectively. These are below the WHO guidelines value for chromium (0.05 mg/l).

But for lead the obtained values were in the margin of the guideline value, it was less than (0.0148 mg/l) for both River Nile and White Nile and less than (0.01409 mg/l) for the Blue Nile while the guideline value is (0.01

mg/l).

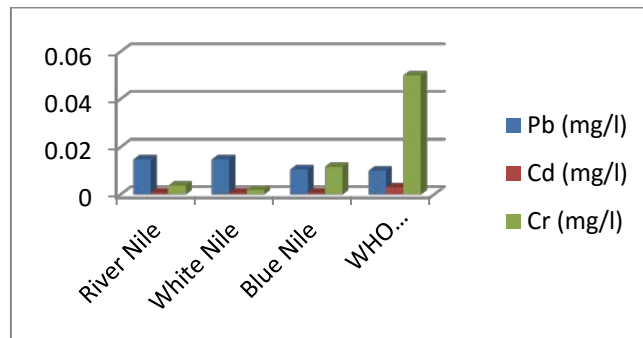


Figure 1: Concentrations of Pb, Cd, and Cr in the River, White and Blue Niles and the guideline values of WHO

Then the concentrations obtained for lead and cadmium in the White Nile and Blue Nile, as the main River Nile tributaries, was compared with those obtained from the previous studies.

3.1. White Nile

For the White Nile the comparison result is shown in table (2) and represented graphically in figure (2). We can notice a sharp increase in the concentration of lead in White Nile throughout the years. It increased from less than (0.0001 mg/l) in year 2006 to (0.0002964 mg/l) in year 2007, increased by 196%, to less than (0.0148 mg/l) in year 2016, increased by 98%. In case of cadmium in the White Nile, its concentration increased by 300% between year 2006 and 2007 where it was (0.000002 mg/l) in 2006 and (0.0000086 mg/l) in year 2007. Then it increased by 104% in year 2016 because its concentration reached to less than (0.0009 mg/l).

Table 2: Concentrations of Lead and cadmium in the White Nile River for three periods of time

Parameters conc.	2006 ^[3]	2007 ^[4]	2016
Pb (mg/l)	<0.0001	0.0002964	<0.0148
Cd (mg/l)	0.000002	0.0000086	<0.0009

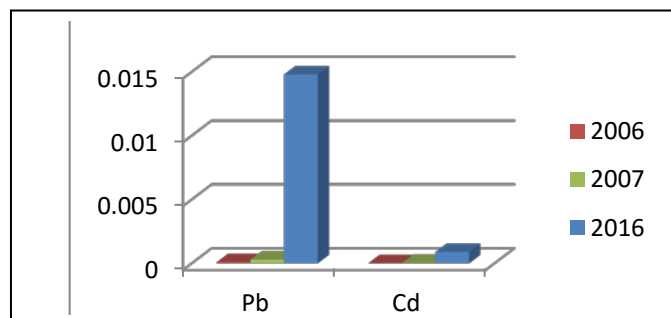


Figure 2: Concentrations (in mg/l) of Lead and cadmium in the White Nile River for three periods of time

3.2 Blue Nile

For the Blue Nile, the comparison result is tabulated in table (3) and represented graphically in figure (3). The lead concentration was not detected in the Blue Nile in 2007, but it reached a value of (0.01049 mg/l) in 2016 showing increase of about 1998% from year 2006 where its concentration was (0.0005 mg/l). Cadmium concentration in Blue Nile dropped in year 2007 (0.0000006 mg/l) from those concentration registered in year 2006 (0.000008 mg/l) but increased by 1499% (to a level of 0.0009mg/l) in 2016.

If the increment goes in the same way the concentration of such pollutants may reach values that exceeding both national and international standards.

Table 3: Concentrations of Lead and cadmium in the Blue Nile River for three periods of time

Parameters conc.	2006 ^[3]	2007 ^[4]	2016
Pb (mg/l)	0.0005	ND*	0.01049
Cd (mg/l)	0.000008	0.0000006	<0.0009

* Not Detected

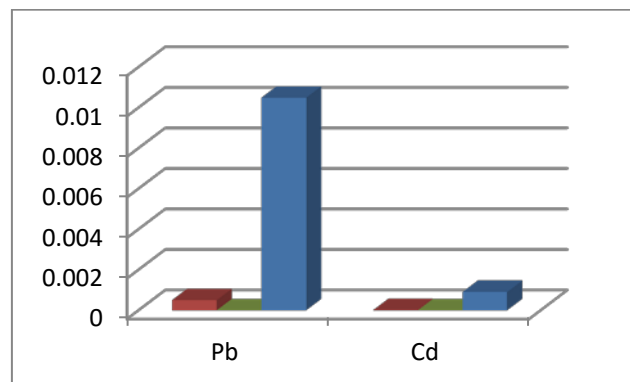


Figure 3: Concentrations (in mg/l) of Lead and cadmium in the Blue Nile River for three periods of time

Degree and methods of water treatment depends on the nature of source, quality of water at source and purpose for which it should be supplied [1].

As yet no treatment facilities for removing heavy metals in the water supply plants that use River Nile, White Nile and Blue Nile as their intake sources because water treatment processes in Khartoum state were designed according to previous quality of water resources. It is clear that this quality is going to be changed due to buildup of certain pollutants such as heavy metals and these levels of concentration may be present in the distributed drinking water. As a result some concern about possible adverse health effects is expected if such materials were consumed over long periods and in large quantities, especially in a hot country like Sudan where the drinking water per capita consumption is supposed to be very high in comparison with cold countries. Heavy metals are toxic and tend to bio accumulate in living organism including human being until reaching a fetal

concentration.

Existing treatment technologies for such pollutants needs high capital investment and operation and maintenance costs. Development of environmentally and economically sound treatment processes are needed for the control of such pollutants from Khartoum state surface water resources. Application of nanotechnology that results in improved water treatment options is highly recommended. Carbon nanotubes (CNTs) show adsorption capability and high adsorption efficiency for removal of heavy metals such as lead. [7]. However, risk assessment is required to evaluate potential risks associated with such materials.

4. Conclusions

Heavy metals concentration in the River Nile, White Nile and Blue Nile in terms of cadmium, and chromium were found to be within the WHO guideline levels for drinking water, but for lead it was in the marginal level.

However when comparing the concentration obtained in this study with those in two previous studies, it was revealed that there is a regular built up of heavy metals concentration in the River Nile tributaries; White Nile and Blue Nile.

Development of environmentally and economically sound treatment processes are needed for the control of such pollutants from Khartoum state surface water resources. Using nanotechnology products, such as Carbon nanotubes (CNTs), for the removal of heavy metals is highly recommended.

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References

- [1]. S.C. Bhatia. Environmental Chemistry. New Delhi, India: CBS publishers & distributors Pvt. Ltd, 2010, pp. 80- 82
- [2]. O.M. Haga, S. Glynn. "Introducing and implementing an EMS in Khartoum State Water Corporation". Nile Basin Water Science & Engineering Journal, vol. 6, pp. 45, 2013.
- [3]. O.A. Bastawy. "Effect of Khartoum City for Water Quality of the River Nile- changes of Water quality along the River Nile" Master thesis, LinkÖping University, Sweden, 2007.
- [4]. I. Yosif, A.I. Omer, M.H. Basheer, T. Mahgoub, F. Hassan, A. Abdelhameed "Assessment of Water Supply Sources and System of Potable Water in Khartoum Metropolitan in Relation to Liquid

- Disposal”. Capacity building research. UNISCO- Chair in water resources. Omdurman Islamic University. Sudan. 2010.
- [5]. A.S. Hamid, D.I. Alim, E.M. Babiker, H. A. Saad “Assessment of Heavy Metal Pollution in the White Nile River in the Sudan”. International Journal of Advanced Research, Volume 3, 2015
- [6]. World Health Organization. “Guidelines for drinking water quality”. Switzerland ISBN 9241546964. 2006.
- [7]. G.A. Mansoori, T. Rohani.Bastami, A. Ahmadpour, Eshaghi. “Environmental application of nanotechnology”. Annual Review of Nano Research, Vol.2, pp. 35, 2008.